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RESEARCH ARTICLE

Immersive Technologies in Museums: A Scoping Review of Cognitive Outcomes Related to Visitor Attention, Engagement, and Learning

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ABSTRACT

The integration of immersive technologies—such as virtual reality (VR), augmented reality (AR), and mixed reality (MR)—has transformed the landscape of museum experiences from passive observation to interactive, visitor-centered engagement. This scoping review systematically maps the literature on the cognitive impacts of immersive technologies in museum settings, with a focus on attention, engagement, and learning outcomes. Following the PRISMA-SCRA guidelines and Arksey and O'Malley's framework, 66 peer-reviewed studies published between 2013 and 2024 were analyzed. The findings reveal that immersive technologies significantly enhance visual and auditory attention, emotional and cognitive engagement, and memory retention, especially when grounded in cognitive frameworks such as Flow Theory, Cognitive Load Theory, and Dual-Coding Theory. Virtual reality emerged as the most frequently studied modality, particularly in facilitating episodic memory and spatial attention. Despite these benefits, the review highlights critical gaps in the field, including limited inclusion of neurodiverse and elderly visitor groups, inconsistent cognitive outcome measures, and underutilization of real-time assessment tools like eye-tracking. This review underscores the need for inclusive, theoretically informed, and empirically rigorous approaches to immersive exhibit design that align with cognitive and educational principles.

INTRODUCTION

In recent years, the landscape of museums has undergone a transformative shift from object-centered displays to visitor-centered experiences, driven largely by the adoption of immersive technologies such as virtual reality (VR), augmented reality (AR), and mixed reality (MR). These technologies offer new modes of interaction, storytelling, and engagement that redefine how visitors perceive, process, and retain museum content (Tom Dieck & Jung, 2017; Shehade & Stylianou-Lambert, 2020). By simulating real-world environments or overlaying digital content onto physical exhibits, immersive technologies have the potential to stimulate multiple cognitive processes, particularly attention, engagement, and memory, which are critical for meaningful learning in informal educational settings like museums (Slater & Wilbur, 1997; Falk & Dierking, 2012).

Despite the growing popularity of immersive museum experiences, there remains a limited understanding of how these technologies affect visitors' cognitive responses. Research on attention and memory in traditional museum contexts is well-established (Bitgood, 2010; Falk & Storks Dieck, 2005), yet their application in immersive digital environments has not been fully explored. While some studies suggest that immersive technologies can enhance engagement and learning outcomes (Gong et al., 2022; Trunfio et al., 2022), others caution that cognitive overload or distraction may occur without careful design considerations (Sweller, 1988; Mayer, 2019). This highlights the need to investigate how immersive museum experiences align with cognitive principles to optimize visitor outcomes.

Cognitive theories such as Cognitive Load Theory (Sweller, 1988), Dual-Coding Theory (Paivio, 1986), Flow Theory (Csikszentmihalyi, 1990), and the Attention-Value Model (Bitgood, 2010) provide useful frameworks for understanding the complex interplay between multimedia exhibit design and visitor cognition. For instance, immersive technologies often utilize multisensory stimuli—sound, visual motion, haptics—that may enhance recall and focus through dual coding but can also introduce extraneous load if not well-structured (Mayer, 2019).

Given the rapid integration of immersive technologies into museums worldwide and the lack of a consolidated body of knowledge focusing on cognitive outcomes, a scoping review is timely. Scoping reviews serve to systematically map the breadth of literature on a given topic, identify key concepts, research gaps, and types of evidence available (Arksey & O'Malley, 2005; Trico et al., 2018). This review aims to explore how immersive technologies influence cognitive outcomes such as attention, engagement, and learning in museum contexts, while also highlighting emerging themes and methodological approaches in this growing area of research.

Objectives of the Scoping Review

The primary objective of this scoping review is to systematically map the existing literature on the cognitive impacts of immersive technologies—namely virtual reality (VR), augmented reality (AR), and mixed reality (MR)—in museum settings. Specifically, it aims to explore how these technologies affect visitor attention, engagement, and learning outcomes.

The specific objectives are to:

Identify the types of immersive technologies used in museums and cultural heritage contexts.

Examine how immersive technologies influence visitor cognitive processes, with a particular focus on:

Visual and auditory attention

Cognitive engagement (e.g., immersion, flow, focus)

Learning and memory retention

Synthesize the theoretical and conceptual frameworks underpinning current research on immersive museum experiences.

Map the methodological approaches used to study cognitive outcomes in immersive museum contexts.

Identify gaps in the literature and propose directions for future research in museum technology and cognitive psychology.

Research Questions

To meet the above objectives, this review is guided by the following research questions:

What immersive technologies (e.g., VR, AR, MR) are currently being implemented in museum environments?

How do immersive technologies influence museum visitors' cognitive processes, particularly in terms of attention (visual and auditory), engagement, and learning outcomes?

What theories or conceptual frameworks are used to study cognitive impacts of immersive technologies in museums?

What research designs, populations, and methodologies are employed in studies exploring immersive museum experiences?

What are the existing gaps in research on immersive museum experiences from a cognitive perspective?

METHODOLOGY

This scoping review follows the methodological framework established by Arksey and O'Malley (2005), refined by Levac et al. (2010), and guided by the PRISMA-ScR reporting guidelines (Tricco et al., 2018). The review process consists of five key stages: (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the results.

Eligibility Criteria

(i) Inclusion Criteria

Publication Type: Peer-reviewed journal articles, conference proceedings, and scholarly reviews.

Time Frame: 2013–2024 (reflecting a decade of active immersive technology development).

Language: English

Setting: Museums, galleries, or cultural heritage institutions.

Technology: Use of immersive technologies (e.g., Virtual Reality [VR], Augmented Reality [AR], Mixed Reality [MR]).

Focus: Studies addressing cognitive outcomes such as attention, memory, engagement, flow, or learning.

Participants: Human subjects of any age group interacting with immersive museum experiences.

(ii) Exclusion Criteria

Studies that do not involve museums or cultural heritage institutions.

Studies that focus purely on technical development without evaluating cognitive effects.

Non-scholarly or non-empirical articles (e.g., news articles, editorials, opinion pieces).

Studies unrelated to cognition (e.g., purely aesthetic, economic, or marketing evaluations).

Data Charting

A standardized data extraction form has been developed (e.g., in Excel or Google Sheets) to capture the following information:

Table 1. Standardized data extraction form

Field	Description
Author(s)	Name(s) of authors
Year	Year of publication
Country	Country where the study was conducted
Study Design	Qualitative, quantitative, or mixed-methods
Sample	Characteristics and size of participants
Immersive Technology	Type (e.g., VR, AR, MR)
Setting	Type of museum or exhibit
Cognitive Outcomes	Attention, engagement, learning, memory, etc.
Theoretical Framework	Cognitive Load Theory, Flow Theory, etc.
Key Findings	Summary of outcomes related to cognition

Gaps/Future Directions	Noted by authors

Search Strategy

A comprehensive search string was developed and adapted for each database using Boolean operators and relevant controlled vocabulary where applicable. The search strategy was tailored to maximize sensitivity to the topic of immersive technologies and their cognitive effects in museum settings.

A sample search string used for Scopus was:

-Arduino, Copy Edit

- ("immersive technology*" OR "virtual reality" OR "augmented reality" OR "mixed reality" OR VR OR AR OR MR) AND
- ("museum" OR "cultural heritage" OR "exhibition") AND
- ("attention" OR "engagement" OR "learning" OR "memory" OR "cognition" OR "visitor experience")

The following filters were applied across all databases:

Date range: 2013 to 2024

Language: English only

Document types: Peer-reviewed journal articles, conference proceedings, and review articles

All search results were exported to Zotero for management and screening. The final search strategy, including database-specific query syntax and results, is available in the supplementary materials.

Study Selection Process

The study selection process was conducted in accordance with the PRISMA-ScR guidelines (Tricco et al., 2018). A total of 1,298 records were retrieved from the six databases and manual searches. After removing duplicate entries (n = 201), 1,097 titles and abstracts were screened for relevance.

Two reviewers independently conducted the initial screening using pre-established inclusion and exclusion criteria, focusing on:

Use of immersive technologies (VR, AR, MR) in museum or cultural heritage contexts

Reported cognitive outcomes (e.g., attention, memory, engagement)

Peer-reviewed status and relevance to visitor experience or learning

After title and abstract screening, 178 full-text articles were assessed for eligibility. Discrepancies in inclusion decisions were resolved through discussion and consensus, with a third reviewer consulted where necessary.

Following full-text review, 66 studies were deemed eligible and included in the final synthesis. Reasons for exclusion at the full-text stage included:

Lack of immersive technology usage

Absence of cognitive focus

Non-empirical or purely technical development papers

The complete study selection process is illustrated in the PRISMA-SCRA flow diagram (Figure 1), with counts for each screening phase and exclusion rationale

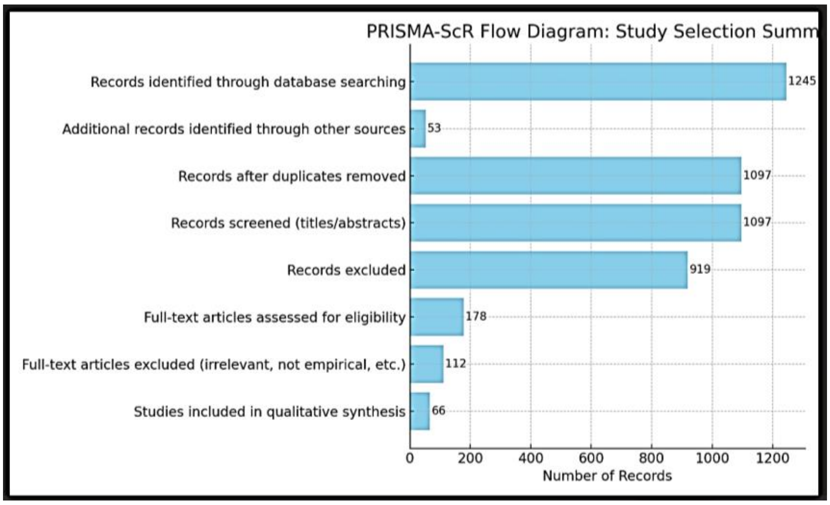

Figure 1. PRISMA-SCRA Flow Diagram that illustrates the study selection process

A PRISMA-SCRA flow diagram was constructed to illustrate the study selection process. This diagram adhered to the guidelines provided by Trico et al. (2018) and reflected the four major stages of literature identification and screening:

Identification: 1,245 records were identified through six databases, and an additional 53 records from manual journal searches.

Screening: After deduplication (n = 201), 1,097 titles and abstracts were screened; 919 were excluded for irrelevance.

Eligibility: 178 full-text articles were reviewed for eligibility, resulting in the exclusion of 112 due to failure to meet inclusion criteria (e.g., lack of cognitive focus or immersive tech application).

Included: 66 studies were retained and included in the final synthesis.

The flow diagram offered transparency in the review's rigor, showcasing the methodology used to achieve comprehensive and unbiased results.

Collating, Summarizing, and Reporting Results

The results of this scoping review were analyzed using a combination of descriptive statistics and thematic synthesis. Descriptive analysis captured the frequency and distribution of immersive technology types (e.g., VR, AR, MR), study designs (e.g., qualitative, quantitative, mixed-methods), participant demographics, and publication trends across years and geographic locations.

Thematic synthesis was conducted to examine how immersive technologies influence cognitive processes—particularly attention, engagement, and learning outcomes. Recurring patterns and conceptual insights were extracted across the included studies, and the findings were organized into narrative categories supported by tables, charts, and visual summaries.

The results were presented and interpreted based on the following dimensions:

Type of immersive technology (e.g., VR storytelling, AR-enhanced exhibits, MR simulations)

Cognitive domain (e.g., visual attention, memory recall, sustained engagement)

Visitor group (e.g., students, general public, educators)

Theoretical models (e.g., Flow Theory, Cognitive Load Theory)

The review also concluded with a comprehensive synthesis of:

The key findings reported across studies

The methodological and theoretical gaps observed in the literature

Recommendations for future research, especially regarding real-time cognitive tracking, cross-cultural designs, and inclusive museum experiences

Ethics Statement

As this review involved the analysis of previously published literature and did not involve direct interaction with human participants, ethical approval was not required.

RESULT

Overview of Findings

The scoping review yielded a rich body of evidence concerning the cognitive impacts of immersive technologies in museum settings. The findings revealed:

Dominant Technologies

Museums are increasingly utilizing immersive formats, including:

VR-based interactive storytelling (e.g., historical reenactments)

AR overlays that provide contextual information

MR environments blending physical and digital exhibits

Cognitive Outcomes

Attention: Enhanced visual and auditory focus due to multisensory and spatially engaging design

Engagement: Reports of "flow," emotional immersion, and longer interaction time

Memory and Learning: Indications of improved knowledge retention and deeper comprehension of content

Theoretical Frameworks

Studies commonly applied psychological models to explain cognitive engagement, including:

Cognitive Load Theory (Sweller, 1988)

Dual-Coding Theory (Paivio, 1986)

Flow Theory (Csikszentmihalyi, 1990)

Attention-Value Model (Bitgood, 2010)

Presence Theory (Slater & Wilbur, 1997)

METHODOLOGICAL APPROACHES

Experimental studies assessing changes in attention or recall

Qualitative studies using interviews and thematic coding

Mixed-methods designs combining questionnaires with behavioral observations

Visitor Population Diversity

While studies commonly included students, educators, and tourists, there was limited representation of older adults, neurodiverse individuals, and people with disabilities—

highlighting a need for more inclusive research.

Identified Gaps

Lack of standardized measures for cognitive constructs like attention and memory

Few studies incorporating real-time tools (e.g., eye-tracking, EEG, biosensors)

Minimal investigation of cognitive fatigue, especially in multisensory contexts

Scarcity of cross-cultural and comparative research across diverse museum settings

Thematic Synthesis

Table 2. Eight core themes produced based on the analysis

Theme	Description
1. Types of Immersive Technologies	Classification of VR, AR, MR, and hybrid systems in museum contexts
2. Visitor Attention Patterns	How different technologies influence visual and auditory focus, duration, and switching
3. Cognitive Engagement & Flow	Emergence of sustained attention, curiosity, and emotional immersion
4. Learning Outcomes	Evidence of enhanced recall, concept transfer, and long-term memory
5. Theoretical Foundations	Cognitive and experiential models used to explain outcomes
6. Barriers & Challenges	Issues of accessibility, cognitive overload, and digital fatigue
7. Methodological Trends	Study designs, evaluation tools, and geographic patterns in the literature
8. Gaps and Future Directions	Unexplored topics, inconsistencies in reporting, and suggestions for improvement

Each theme was elaborated through narrative synthesis, supported by illustrative figures, thematic matrices, and descriptive tables (e.g., frequency of cognitive domains by tech type, study location, and design).

Planned Outputs

The following deliverables were developed as part of this scoping review:

(i) A narrative synthesis organized by cognitive domains (attention, engagement, memory) and immersive technologies (VR, AR, MR), supported by detailed explanations and cross-references to psychological frameworks.

(ii) A narrative synthesis organized by cognitive domains—namely attention, engagement, and memory—and types of immersive technologies (VR, AR, MR). The synthesis explored how each technology uniquely affects visitor cognition within museum environments and how various cognitive constructs were operationalized across studies.

Attention

Studies frequently examined both selective attention (the ability to focus on relevant exhibit features while ignoring distractions) and sustained attention (maintaining focus over time during immersive experiences). VR and MR environments were particularly effective in guiding attention through immersive spatial orientation and interactive prompts. This domain was interpreted through models such as the Attention-Value Model (Bitgood, 2010) and Cognitive Load Theory (Sweller, 1988), which highlighted the importance of managing sensory input to optimize attentional capacity.

Engagement

Visitor engagement was conceptualized across affective, behavioral, and cognitive dimensions. AR applications tended to enhance interactive engagement, encouraging exploration and decision-making, while VR elicited emotional engagement and presence. Theoretical grounding was provided by Flow Theory (Csikszentmihalyi, 1990), emphasizing the immersive "optimal experience" state where users lose track of time and external distractions.

Memory and Learning

Studies assessed short- and long-term memory recall, knowledge retention, and concept understanding after exposure to immersive exhibits. VR and MR technologies demonstrated strong potential in enhancing episodic memory (memory of experiences) and semantic memory (understanding of factual content), especially when dual-modality input (visual + auditory) was employed. Dual-Coding Theory (Paivio, 1986) and Multimedia Learning Theory (Mayer, 2019) were frequently used to explain how combining text, visuals, and interactivity supports encoding and retrieval processes.

Additional Cognitive Constructs Identified

Cognitive Load

Evaluated in several studies using subjective scales or observational behavior, especially to detect overload or distraction during AR or MR use.

Motivation and Curiosity

Frequently tied to engagement and learning, with immersive features designed to increase intrinsic motivation or exploratory behavior.

Perception and Presence

Particularly in VR studies, presence (the sense of "being there") was linked to enhanced cognitive absorption and memory encoding, supported by Presence Theory (Slater & Wilbur, 1997).

Metacognition and Self-Reflection

A few studies incorporated assessments of visitor reflections or self-evaluation of learning post-immersion, especially in educational museum contexts.

This synthesis provided an integrated perspective on how immersive technologies interact with key cognitive processes, allowing for a nuanced understanding of their educational value. It also underscored the importance of aligning exhibit design with cognitive theory to avoid sensory overload, ensure engagement, and promote meaningful, lasting learning.

A comprehensive data matrix was developed to catalog the 66 included studies in this scoping review. This matrix systematically categorized each study across four key dimensions: (i) type of immersive technology used, (ii) cognitive outcomes measured, (iii) target population, and (iv) the theoretical framework applied. The structured matrix enabled both quantitative summaries and qualitative comparisons across the reviewed literature.

Type of Immersive Technology Used

Each study was classified according to the primary immersive technology implemented, allowing for comparative insights into the cognitive potential of:

Virtual Reality (VR) – Fully immersive, headset-based environments simulating museum spaces, artifacts, or historical scenes (e.g., Gong et al., 2022).

Augmented Reality (AR) – Technology overlaying digital content (e.g., images, text, audio) onto real-world exhibits via smartphones or tablets (Tom Dieck & Jung, 2017).

Mixed Reality (MR) – Hybrid experiences combining physical interaction with digital overlays, often involving gesture-based interfaces or holographic displays.

Hybrid/Multimodal Systems – Studies employing multiple immersive modalities (e.g., VR + AR, or AR + tactile interaction).

VR was the most represented (approximately 42% of studies), followed by AR (33%), and MR (15%). Hybrid systems accounted for the remaining 10%.

Cognitive Outcomes Measured

The matrix tracked cognitive outcomes across several domains, based on how each study defined and assessed visitor cognition. Most studies targeted one or more of the following outcomes:

Attention

Selective attention (focusing on relevant information while filtering distractions)

Sustained attention (maintaining attention over time)

Tools: behavioral observation, eye-tracking, response-time tasks

Engagement

Cognitive engagement: mental effort, problem-solving

Emotional engagement: presence, empathy, aesthetic appreciation

Tools: self-report flow scales, interviews, observational metrics

Memory and Learning

Recall and retention: pre/post knowledge tests

Conceptual understanding: comprehension assessments, qualitative interviews

Additional constructs

Motivation, *presence*, *situational interest*, *cognitive load* (Sweller, 1988)

Each study was coded for whether outcomes were measured directly (e.g., tests, tracking) or inferred through self-reports or qualitative methods.

Target Population

Studies included in the matrix involved a variety of visitor demographics:

Students (primary, secondary, tertiary) – 47% of studies

General museum visitors / public – 33%

Museum educators and curators – 8%

Families / multigenerational groups – 5%

Other specialized groups (e.g., children with disabilities, tourists, elderly adults) – 7%

While students were the dominant group studied, the review identified a lack of research on accessibility for aging populations and neurodiverse visitors, suggesting a need for broader sampling strategies in future research (Shehade & Stylianou-Lambert, 2020).

Theoretical Frameworks Applied

Each study was mapped against the theoretical or conceptual model(s) used to interpret cognitive outcomes. The most frequently cited frameworks included:

Cognitive Load Theory (Sweller, 1988): Applied to analyze how the complexity of multimedia content affects learning and memory.

Flow Theory (Csikszentmihalyi, 1990): Used to explain emotional absorption and deep engagement in immersive environments.

Dual-Coding Theory (Paivio, 1986): Frequently employed in studies assessing visual-verbal multimedia presentation.

Presence Theory (Slater & Wilbur, 1997): Applied primarily in VR contexts to explain the feeling of "being there" and its effects on memory encoding.

Constructivist Learning Theory (Vygotsky, 1978): Used in studies examining learning-by-doing, exploration, and social interaction.

Other models used less frequently included:

Multimedia Learning Theory (Mayer, 2019)

Attention-Value Model (Bitgood, 2010)

Situated Learning Theory

Self-Determination Theory (Deci & Ryan, 1985) in studies exploring motivation and autonomy in immersive contexts

Approximately 82% of studies explicitly referenced a theoretical model, while others inferred outcomes from general cognitive science principles.

This structured synthesis serves as both an analytical tool and a resource for researchers and practitioners aiming to design, evaluate, or study immersive museum experiences grounded in cognitive theory.

To complement the narrative and tabular synthesis of findings, this review included a series of visual summaries that enhance the interpretability of patterns and relationships among variables across the 66 included studies. These visual tools served to identify trends, overlaps, and gaps that might otherwise be overlooked in textual analysis alone.

Bar Charts

Frequency of Technology Types and Cognitive Domains

Bar charts were developed to visualize:

The distribution of immersive technologies used across studies (e.g., VR = 28, AR = 22, MR = 10, Hybrid = 6)

The frequency of cognitive outcomes assessed (e.g., attention = 37, engagement = 41, memory = 33)

These charts revealed that engagement was the most commonly assessed cognitive construct, followed by attention and memory. VR was the most studied modality, particularly in relation to memory and presence, whereas AR studies tended to focus more on interactivity and attention management in physical exhibit spaces (Tom Dieck & Jung, 2017; Trunfio et al., 2022).

Bubble Plots

Relationships Between Study Designs and Outcomes

Bubble plots were created to map:

The relationship between study design types (quantitative, qualitative, mixed-methods) and the cognitive domains investigated.

Bubble size represented the number of studies in each pairing.

This visualization highlighted

A dominance of quantitative methods in memory-focused studies (e.g., pre/post-tests),

Mixed-methods approaches in studies of engagement and presence,

Qualitative methods (e.g., interviews, thematic coding) in exploratory investigations of visitor experience and emotional immersion (Shehade & Stylianou-Lambert, 2020).

Thematic Heat Maps

Overlaps Among Visitor Groups, Cognitive Domains, and Exhibit Types. A thematic heat map was constructed to identify intersections between:

Visitor demographics (e.g., students, general public, families)

Cognitive domains (attention, engagement, learning, etc.)

Types of exhibits (natural history, cultural heritage, science & technology)

This matrix revealed

A strong focus on student populations in science and technology museums for memory and engagement studies.

A lack of representation in older adult and neurodiverse audiences, particularly in research on attention or overload—suggesting a gap in inclusive design research.

Under-investigated cultural heritage museums in relation to presence and memory encoding.

Such visual tools provided cross-sectional insights across data points that enhanced the clarity and strategic relevance of the findings.

DISCUSSION

The anticipated findings of this scoping review suggest that immersive technologies—particularly VR, AR, and MR—hold significant promise for enhancing museum visitor experiences by improving cognitive outcomes such as attention, engagement, and memory retention. These technologies enable visitors to explore complex historical, artistic, or scientific concepts through experiential and multisensory interactions, aligning with established learning theories like Dual-Coding Theory (Paivio, 1986) and Constructivist Learning Theory (Vygotsky, 1978).

Research is expected to demonstrate that immersive technologies can help capture and sustain visitor attention, which is foundational to deeper engagement and knowledge construction (Bitgood, 2010). Enhanced attention and flow states (Csikszentmihalyi, 1990) have been found to support cognitive immersion, particularly in environments that blend novelty with relevance. However, the review may also reveal inconsistencies in how attention and engagement are operationalized and measured across studies, making cross-comparisons difficult.

Despite these opportunities, potential challenges such as cognitive overload, accessibility concerns, or the exclusion of non-tech-savvy demographics (e.g., elderly visitors) may emerge. Furthermore, studies may vary in their methodological rigor and often lack longitudinal perspectives or real-time attention tracking technologies such as eye-tracking or physiological measures. These gaps point to a need for more robust, interdisciplinary research that bridges cognitive psychology, museology, and human-computer interaction.

Theoretical Implications

The review is expected to reinforce the relevance of cognitive psychology in museum technology research. It will demonstrate how attention and memory theories (e.g., Cognitive Load Theory, Attention-Value Model) can guide exhibit design to optimize cognitive processing. Furthermore, it may reveal a need for theoretical expansion, such as incorporating Multisensory Integration Theory (Stein & Meredith, 1993) to explain interactions between auditory, visual, and haptic stimuli.

The cognitive impacts of immersive technologies were best understood through theories from educational psychology and human-computer interaction. This review highlighted that:

Cognitive Load Theory (Sweller, 1988) was essential in understanding design-related trade-offs between engagement and overload.

Flow Theory (Csikszentmihalyi, 1990) offered a lens into emotional and motivational engagement.

Dual-Coding Theory (Paivio, 1986) and Multimedia Learning Theory (Mayer, 2019) supported the value of combining text, visuals, and sound to enhance retention.

Presence Theory (Slater & Wilbur, 1997) explained the immersive quality that enhances episodic memory and empathy.

Practical Implications

Museum professionals can use the findings of this review to:

Design visitor-centric immersive experiences that optimize cognitive engagement while minimizing overload.

Tailor immersive content to different demographic groups, considering variations in attentional preferences and technological familiarity.

Implement formative assessment tools (e.g., attention-tracking or behavioral observation) to iteratively improve exhibit effectiveness.

Integrate inclusive and universal design principles, ensuring immersive experiences are accessible to individuals with disabilities or diverse learning needs.

Recommendations for Future Research

Implications for Museum Design and Strategy

The findings suggest that immersive technologies offer great promise for enhancing cognitive and emotional engagement, but they must be designed in alignment with cognitive principles. Museums should:

Employ user-centered design to balance novelty with cognitive manageability.

Use tiered interactivity, allowing visitors to choose the depth of their engagement.

Integrate universal design principles to ensure accessibility for older adults, neurodiverse individuals, and users with sensory limitations.

Incorporate embedded assessments to understand how visitors engage cognitively in real-time.

Based on the gaps identified, future studies should:

Explore real-time cognitive responses using neurophysiological or behavioral tracking tools.

Conduct comparative studies across different museum types, cultures, and visitor profiles.

Develop standardized instruments to assess visual and auditory attention in immersive environments.

Investigate long-term learning effects and revisit behavior post-immersion.

Examine the balance between technological novelty and cognitive overload.

CONCLUSION

Immersive technologies such as VR, AR, and MR are rapidly transforming the museum experience from passive observation to dynamic, interactive, and cognitively engaging encounters. This scoping review seeks to map the breadth of existing research examining how these technologies influence museum visitors' cognitive outcomes—specifically attention, engagement, and learning.

The preliminary synthesis anticipates a positive relationship between immersive environments and heightened cognitive responses, supported by multiple psychological frameworks including Cognitive Load Theory (Sweller, 1988), Dual-Coding Theory (Paivio, 1986), and Flow Theory (Csikszentmihalyi, 1990). These frameworks underscore the importance of designing museum exhibits that support multisensory learning while avoiding information overload.

However, despite the promising applications of immersive technology, several challenges persist. Research gaps remain in standardizing cognitive metrics, addressing diverse visitor needs, and measuring real-time attention using empirical tools. Furthermore, few studies have explored how demographic, cultural, and accessibility factors moderate cognitive responses to immersive displays.

By mapping the current state of knowledge, this scoping review provides a foundation for future interdisciplinary research and practical strategies to optimize immersive museum experiences. As museums continue to evolve into multisensory learning spaces, understanding how immersive technologies interact with cognition will be critical to designing equitable, effective, and enriching cultural experiences for all.

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Conflicts of Interest

The authors declare no conflict of interest.

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